Experimental study of a porous asphalt

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ABSTRACT Noise pollution is becoming a crucial problem in France as traffic is rapidly increasing. Therefore, quieter pavements are requested by many communities such as Limoges Metropole. The latter ordered the use of a low noise porous asphalt. This product is used as a wearing course. It is characterized by its phonic properties and improved skid resistance. However, due to its high content of voids (≥ 15%), its mechanical properties might not be as optimal as a conventional asphalt (BBSG: Semi-coarse asphalt concrete). Therefore, this work seeks to determine the durability of the requested porous asphalt experimentally. Tension/compression tests were carried out using samples cored from slabs. The experiments were performed for several temperatures (-10, 0, 10, 15, 20 °C) and frequencies (0.1, 0.3, 1, 3, 10 Hz). The results obtained show that the studied porous asphalt is a decent product compared to other asphalts.

Keywords porous asphalt, complex modulus, tension/ compression,

I. INTRODUCTION

Currently, one of the predominant noise sources stems from traffic. It is mainly generated by the contact of a vehicle tire with the road (Freitas, E. et al, 2009). To mitigate this pollution, porous asphalt can be used as it absorbs the sound generated by the tire/pavement interaction. This earliest application of this material dates to the 1967 in the UK. However, it was not frequently applied as UK favored Hot Rolled Asphalt (Ranieri, V., 2005). Since then, many studies were done to assess the efficiency of porous asphalt, hence, leading to its formula's development. However, the durability of porous asphalt remains challenging due to the important presence of pores. The latter reduces severely its strength and fatigue resistance compared to conventional asphalt (Mo, L. T et al, 2010). Nevertheless, Chen, J. S. et al (2012) proved that using a modified polymer binder enhances the mechanical properties of porous asphalt such as its complex modulus. The tests carried out corresponds to the indirect tensile test. Furthermore, Norambuena-Contreras, J. et al (2010) measured the complex modulus of a porous asphalt by ultrasonic transmission. They stated that a correlation factor should be applied to the results of the porous asphalt to attain the correct values. Arshad, A. K., et al (2017), determined the dynamic modulus using SPT test or Simple Performance Tester. The latter is not widely used especially in Europe as it is not included in the Europeans norms. Moreover, the samples were tested for high temperatures (25, 30, 35, 40 & 45 °C). Nonetheless, the results obtained were satisfactory reaching 3000 MPa for a temperature of 25°C and a frequency of 10 Hz. In this paper, a description of the material and method used will be presented. Then, the results obtained will be discussed. This paper aims at determining the complex modulus of a porous asphalt using traction-compression test for temperatures of -10, 0, 10, 15& 20°C and frequencies of 0.1, 0.3,1,3 & 10 Hz. These results will be compared to the ones obtained from a traditional two bending test on trapezoidal samples. In addition, the performance of this asphalt will be compared to a conventional asphalt and a traditional porous asphalt.

II. MATERIAL AND METHOD

A. *Material*

The studied porous asphalt is described as a skid resistance, noise reducing, having drainable capacity asphalt mix (COLAS, 2004). It is characterized by its discontinuous granulometric curve. The latter is made of the fractions (0/2; 2/4; 4/6 mm). Its granular mixture contains a small amount of sand but an important quantity of fillers. Its binder is a modified polymer-based bitumen with a concentration of 5.5%. This formulation induces voids up to 20% that confer numerous advantages such as: phonic properties as it is able to absorb the noise generated from vehicles 'rolling, high adherence and high resistance to rutting. However, no studies have been conducted to measure the rigidity and strength of this porous asphalt.

B. *Method*

The experiments were carried out on cylindrical samples of 75 mm in diameter and 165 mm in height. The latter were cored from slabs manufactured by the company. They were polished to smooth the upper and lower surfaces. Around 16 samples were prepared. However, in this paper, only the results of three cylindrical specimens will be presented.

Before testing the samples, a process specific to this material was developed:

1. Defined surfaces corresponding to the size of a gauge were prepared by clogging the pores under it using a paste.
2. Gauges were transferred from a smooth surface (mirror) using a Teflon tape to the sample.
3. They were glued using (M bond adhesive) and coated with a protection layer (M-coat).

With the gauges glued to the sample, the latter is ready to be used for testing. Then tension/compression tests were carried out for each specimen using a hydraulic press equipped with a measuring cell, used to control axial strain. A climate chamber was used for temperature conditioning. Five frequencies (0.1, 0.3, 1, 3 and 10 Hz) and five temperatures (-10, 0, 10, 15, 20°C) were defined to a selected sample. The chosen specimen was glued to the bases of the round grips that where tighten evenly using screws. Then, the gauges were connected to an acquisition system to measure the elongation of the gages in response to the applied strain. For a constant frequency and temperature, an axial strain amplitude of 50 micro deformations was imposed. The machine can provide the strain and stress applied on the specimen. These results allow the computation of the complex modulus. Since the sinusoidal strain applied is in the linear domain, the complex modulus was calculated using the following equation:

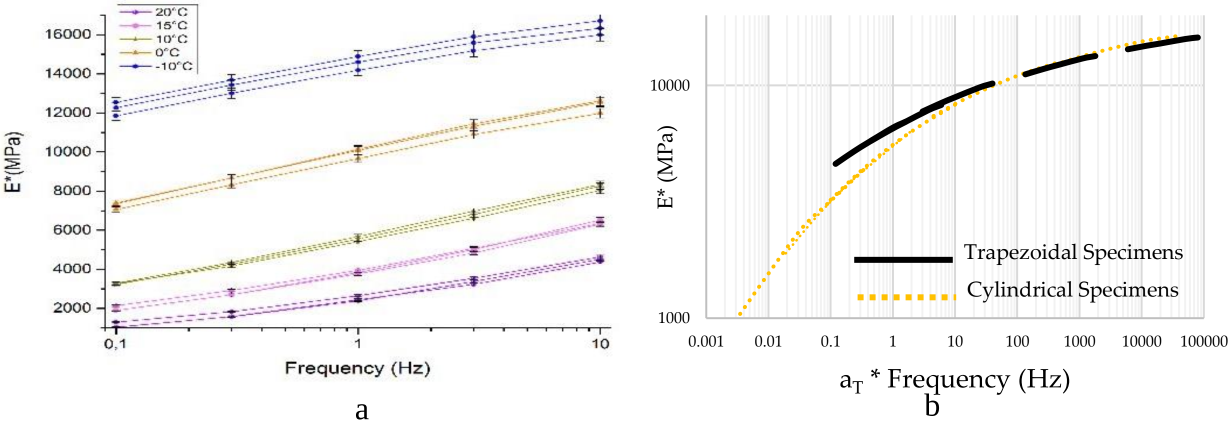
$$E^* = \frac{\sigma_{max} - \sigma_{min}}{\varepsilon_{max} - \varepsilon_{min}}$$

(1)

Finally, the measurements were retrieved and were fitted using the moving average. The results are presented in the subsequent section

III. RESULTS

Five specimens were tested (Three of them are cylindrical and two of them are trapezoidal). They were characterized by 16% of voids. This percentage was obtained by calculating the ratio of the actual density over the apparent one. The complex modulus was computed for various temperatures and frequencies. These values are summarized in Fig.1. a. The latter presents the isotherms (20, 10, 0, -10, 10°C) of cylindrical specimens. Using this graph, constructing a master curve was feasible. These results were compared with a master curve corresponding to the same product using two-point bending test on trapezoidal specimens. These values were provided by the manufacturer. A discrepancy of the slopes' curves is noticeable due to the form difference of the samples. As, cylindrical form is more homogeneous than a trapezoidal one Fig.1. b. This comparison validates the results of the complex modulus obtained using a tension-compression test compared to a conventional two-point bending test on trapezoidal samples.



a

b

FIGURE 1. **Isotherms of cylindrical specimens (a) Master curves of cylindrical specimens and trapezoidal specimens (b)**

Moreover, the values of the studied asphalt were compared to those of a conventional asphalt (BBSG) and a typical porous asphalt (PMB) usually used for its drainable capacity. This HMA is made from a discontinuous granulometric curve of 0/2 & 6/10 (Olard, F. 2003). The results obtained were credible as the values were almost two times higher than the PMB. Albeit its rigidity is not as notable as a BBSG, its performance remains satisfying compared to a typical porous asphalt (Fig 2).

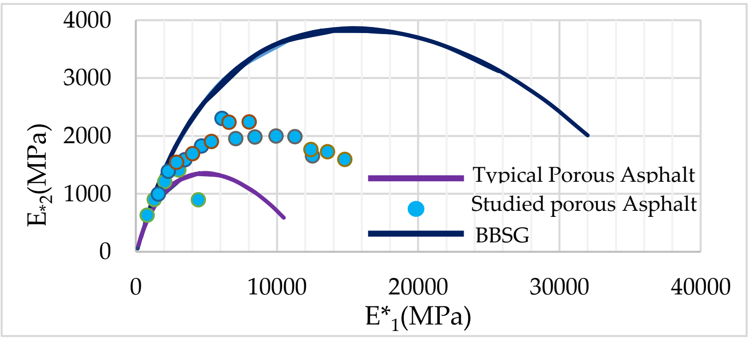


FIGURE 2. **Cole-Cole diagram of the studied porous asphalt, BBSG and a typical porous Asphalt**

IV. CONCLUSION

The studied porous asphalt seems to be balancing phonic and mechanical properties. These characteristics were attainable due to the use of the modified bitumen in its formula. The binder was modified with styrene-butadiene-styrene. The formulation of the studied HMA was realized by the company. The values obtained showed that the studied HMA has a more elastic behavior than conventional asphalts. The complex modulus of the studied porous asphalt seems to be two times more important than a conventional porous asphalt. In parallel of this work, fatigue tests are being performed to assess its durability. In addition, experiments are being conducted to calibrate the testing system in order to obtain the right phase angles corresponding to the measured complex modulus.

V. ACKNOWLEDGEMENT

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